



# Satellite Irradiance Models and Datasets

Adam Kankiewicz  
Solar Resource Specialist  
2014 PV Sandia Performance  
Modeling Workshop May 5, 2014



Clean Power Research®

Copyright © 2014 Clean Power Research, L.L.C

v040714

# Agenda

- The Evolution of Solar Irradiance Modeling and Datasets
- Satellite-based Irradiance Modeling
- TMY Data Considerations
- Which Data Should I Use?

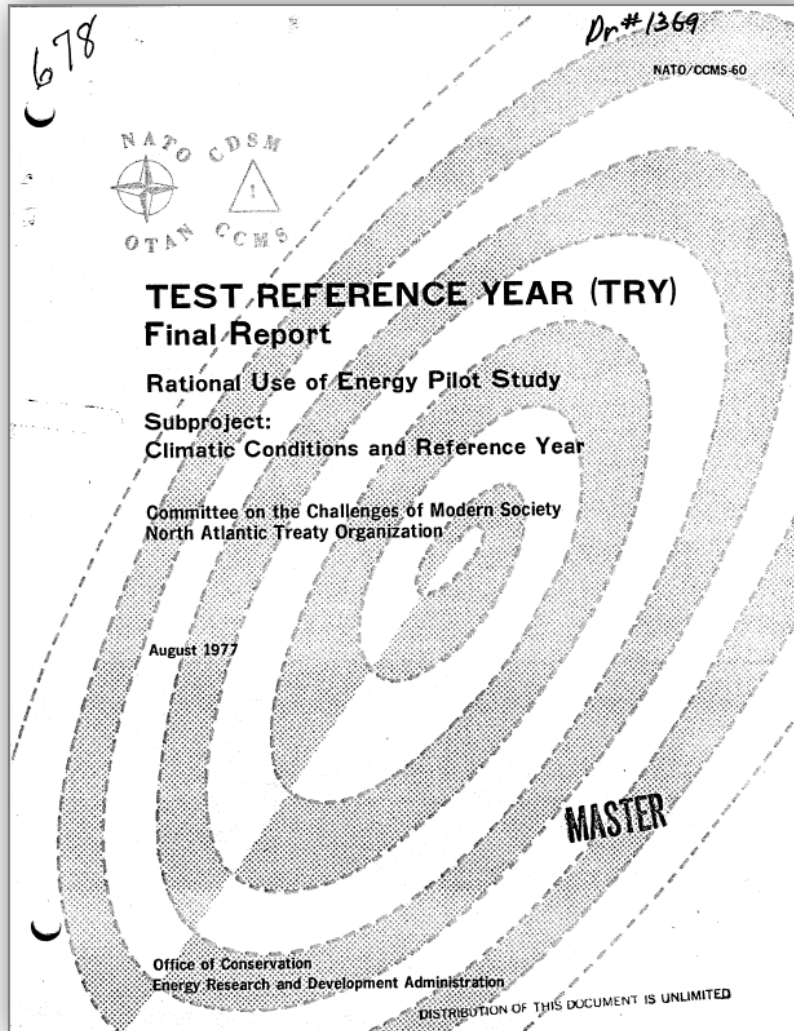


# Agenda

- The Evolution of Solar Irradiance Modeling and Datasets
- Satellite-based Irradiance Modeling
- TMY Data Considerations
- Which Data Should I Use?



# The Origins of TMY



## ABSTRACT

The Test Reference Year (TRY) for a specified location is a data collection consisting of 8760 sets of hourly weather data. Its main objective is to provide data for computerized calculations regarding energy conservation, energy consumption in buildings, and indoor climate.

This report recommends a suitable format for such a TRY, describes which weather data are mandatory for such a TRY to meet the main objective, and recommends how it should be published. The report does not recommend any specific procedure for generating or selecting a TRY for a given location.

"It's main objective is to provide data for computerized calculations regarding energy conservation, energy consumption in buildings and indoor climate."

# What is TMY?

- Year long file of hourly (“8760”) weather data pulled from a bank of longer historical data coverage
- Meant to typify average weather conditions at a location (P50)
- TMY data are consistent at the monthly level
- Current NREL NSRDB TMY2 and TMY3 weighting scheme:

GHI: 25%

DNI: 25%

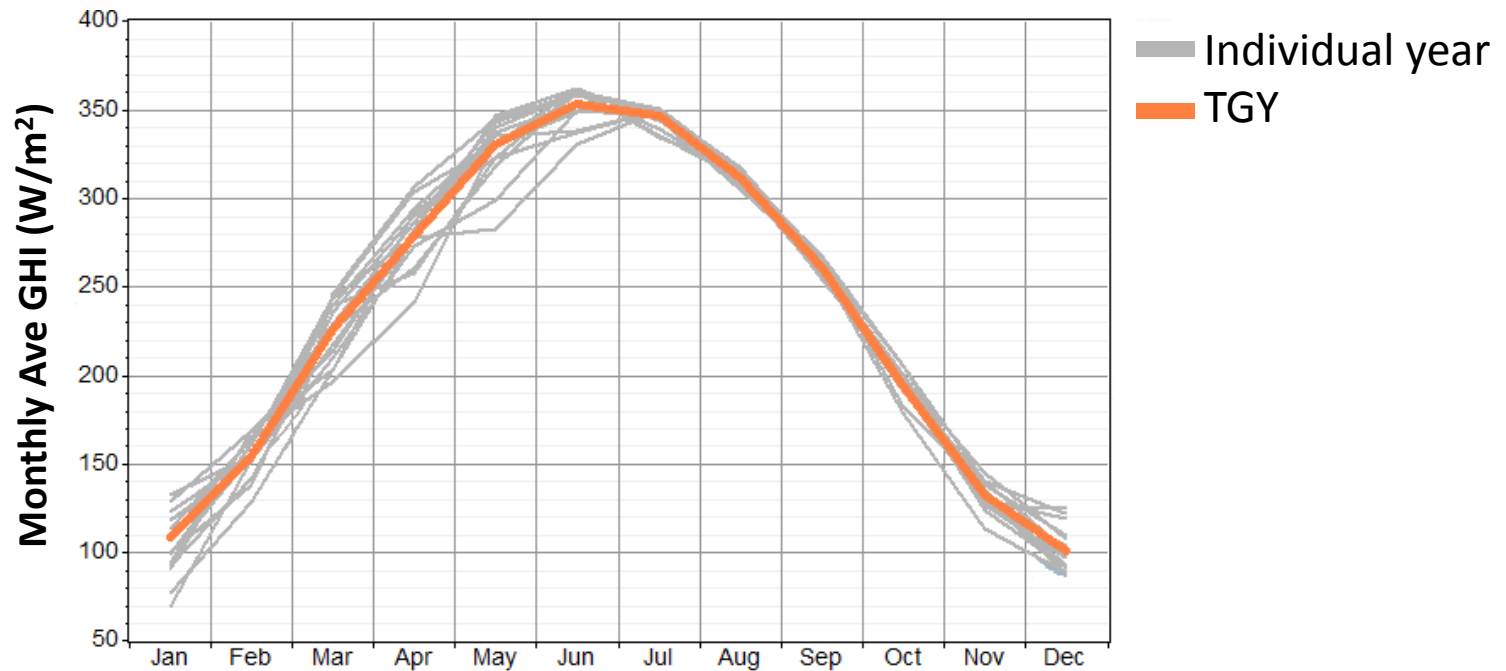
Met data (T, Td, WS): 50%



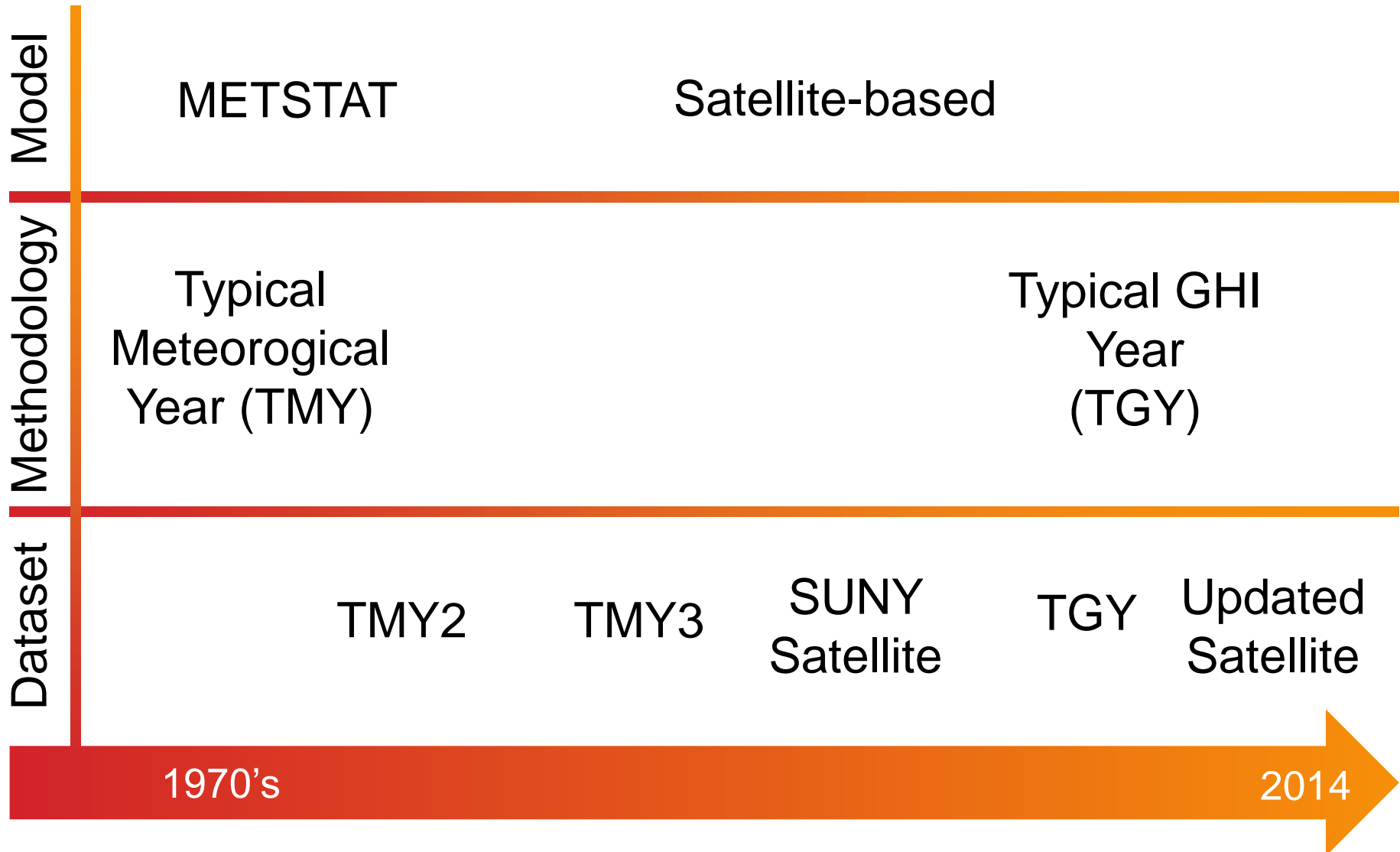
Clean Power Research®

# What is TGY?

- Typical GHI Year (TGY)
- Same concept as TMY but with weighting based solely on GHI



# The Evolution of Irradiance Modeling

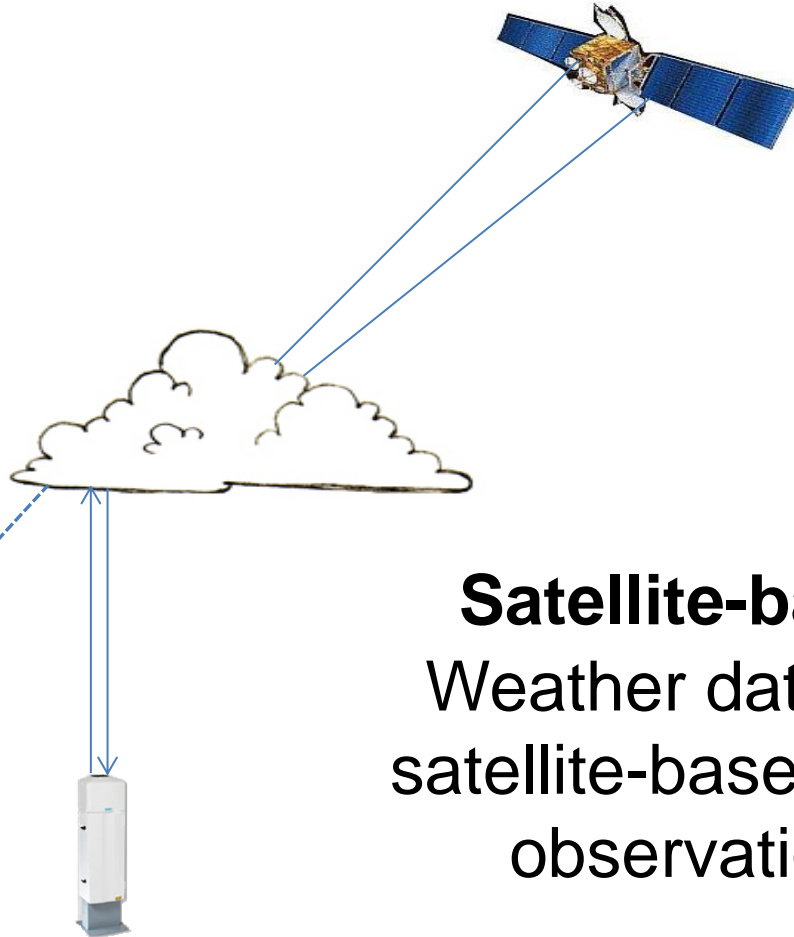


# Modeling Surface Irradiance Data

## **METSTAT**

(Meteorological  
Statistical)

Weather data plus  
ground-based cloud  
observations



## **Satellite-based**

Weather data plus  
satellite-based cloud  
observations



Clean Power Research®

**Primary difference is how clouds  
are observed and handled!**



# Agenda

- The Evolution of Solar Irradiance Modeling and Datasets
- **Satellite-based Irradiance Modeling**
- TMY Data Considerations
- Which Data Should I Use?



# Satellite Model Components

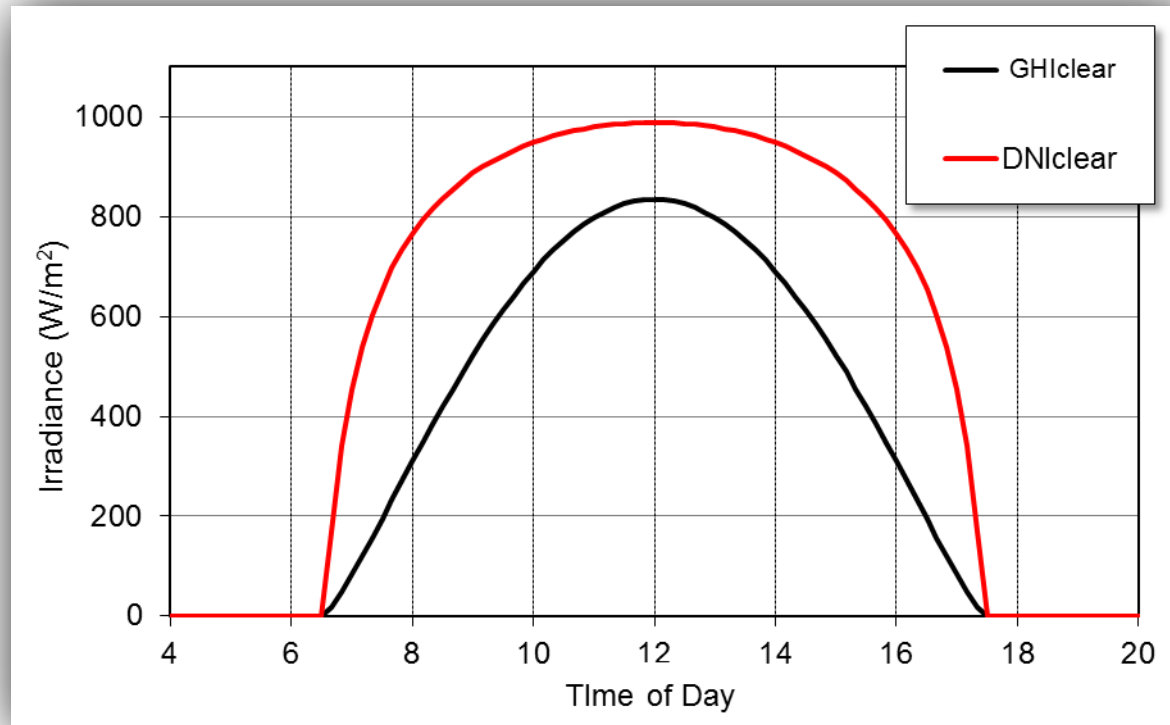
Radiative Transfer Model  
(quasi-physical)

+

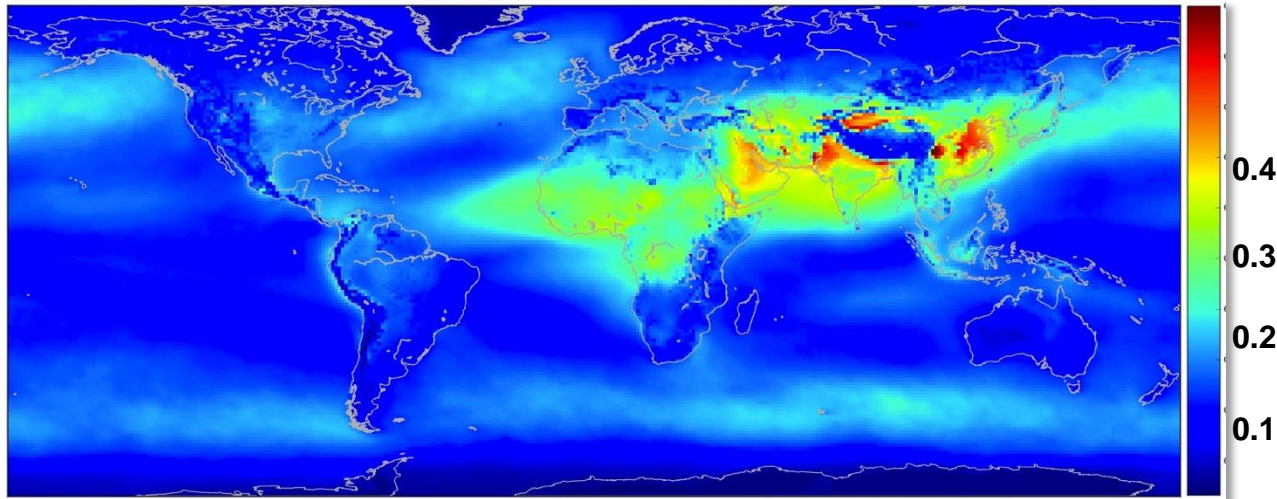
Cloud Modulation  
(largely empirical)



# Radiative Transfer Model

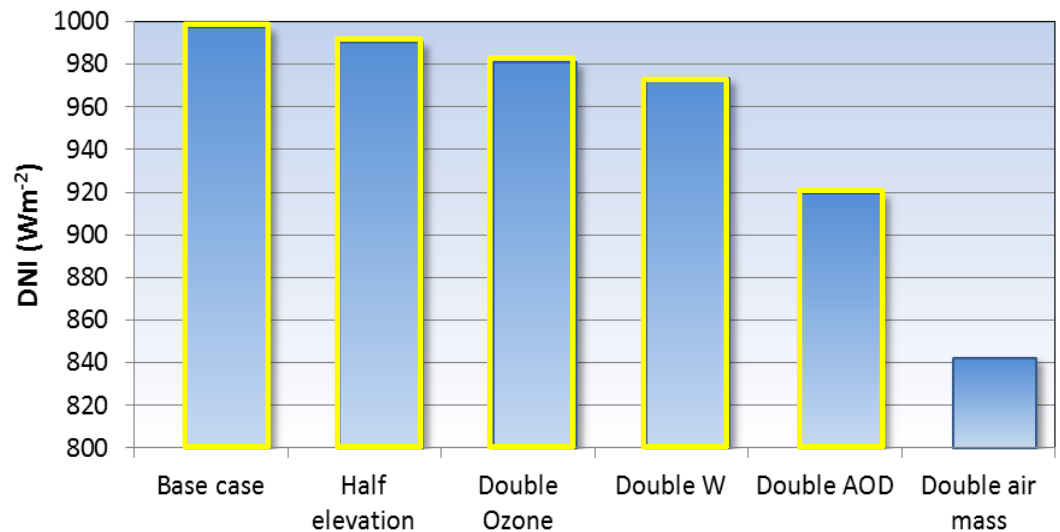


# Model Sensitivities



**AOD**

- W** Precipitable water
- O<sub>3</sub>** Ozone
- H** Altitude



# What GOES into a Satellite Model?

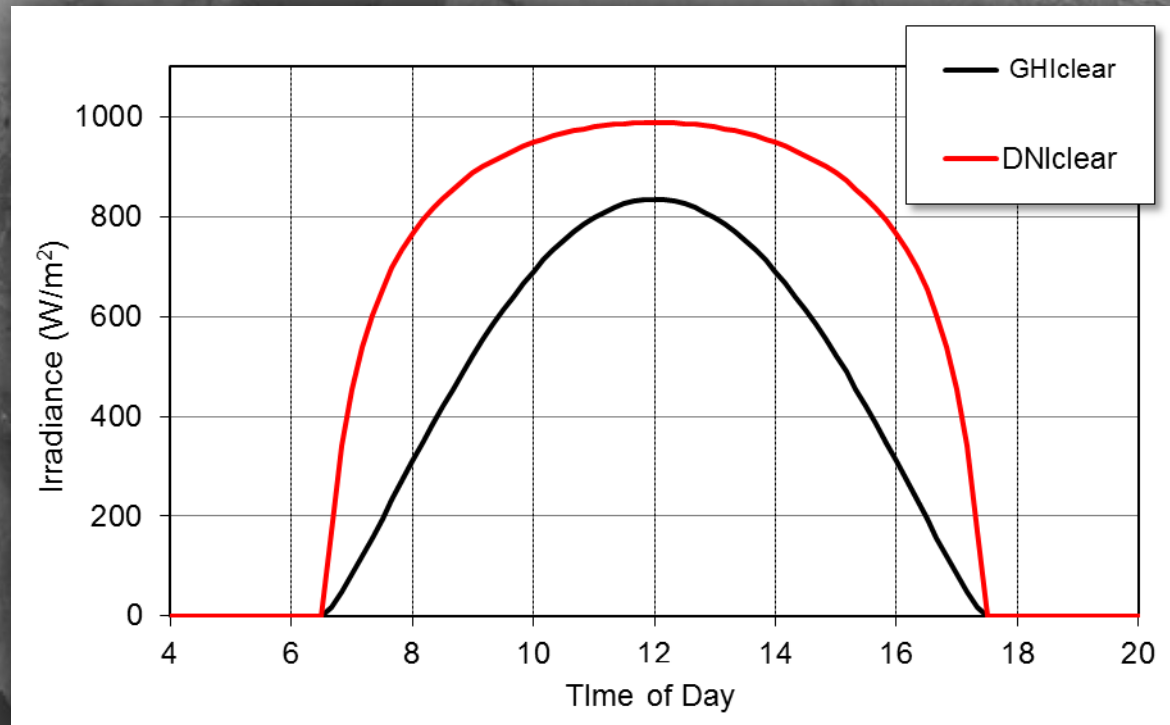
Radiative Transfer Model  
(quasi-physical)

+

Cloud Modulation  
(largely empirical)

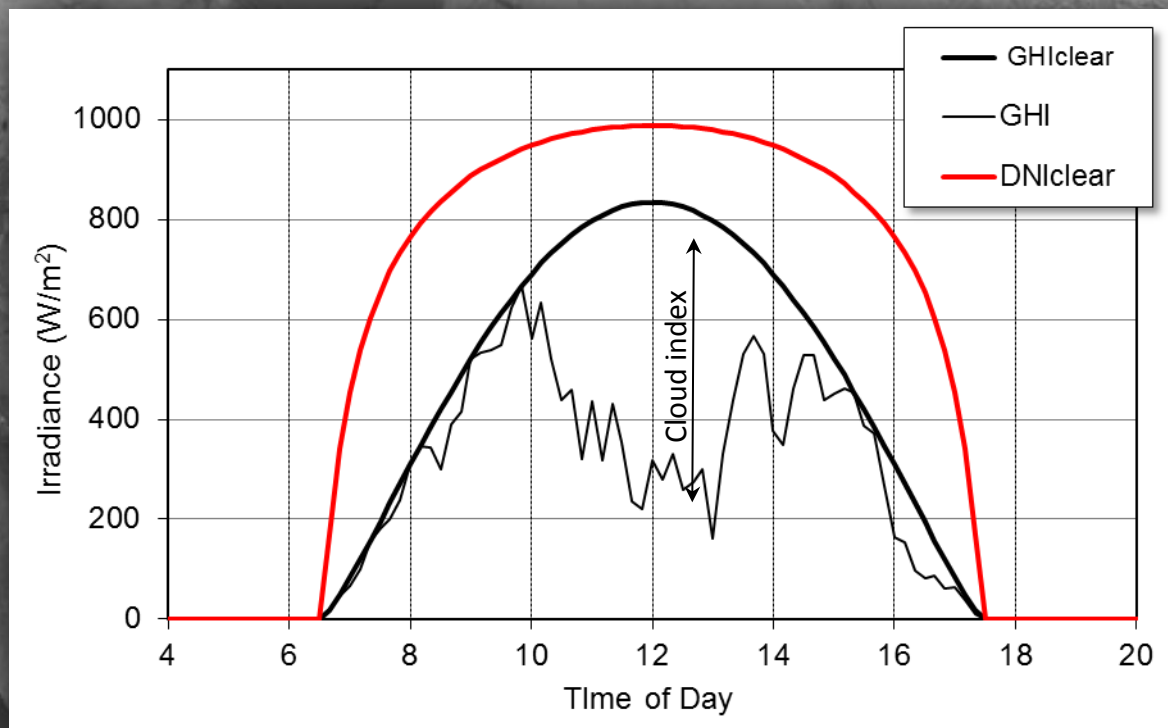


# Cloud Modulation



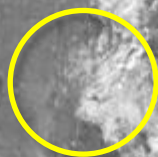


# Cloud Modulation

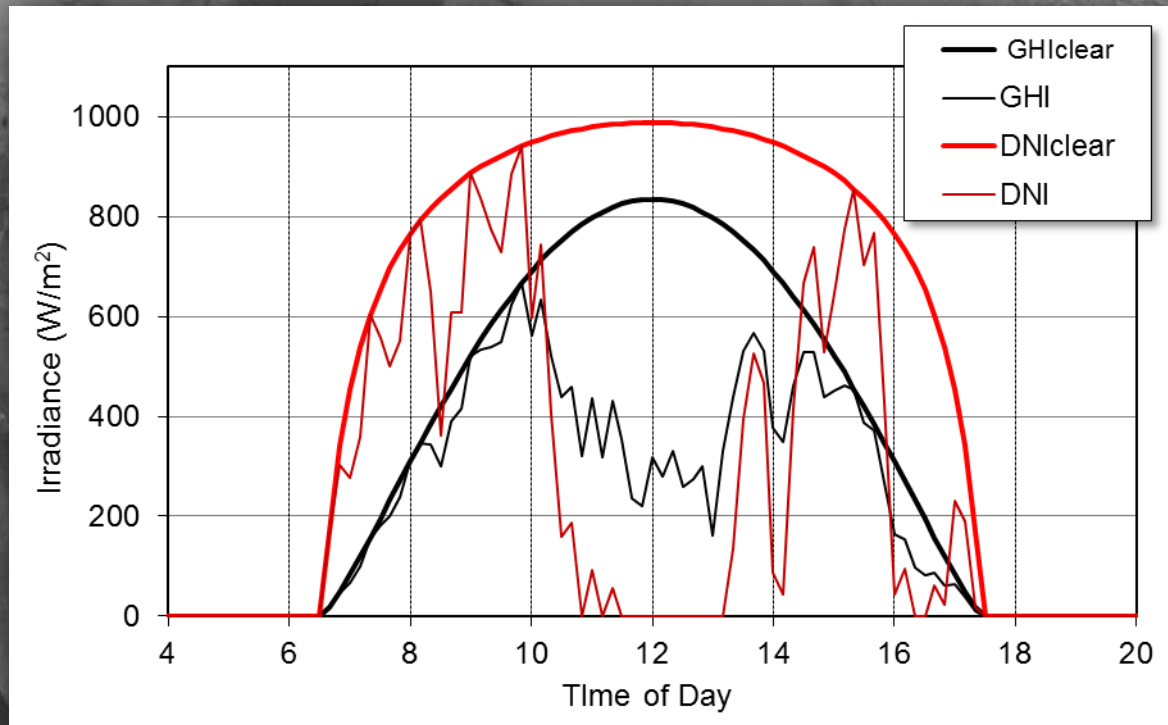


**DARK (clear)**

**WHITE (cloudy)**

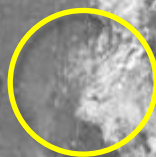


# DNI Extrapolation with DIRINDEX



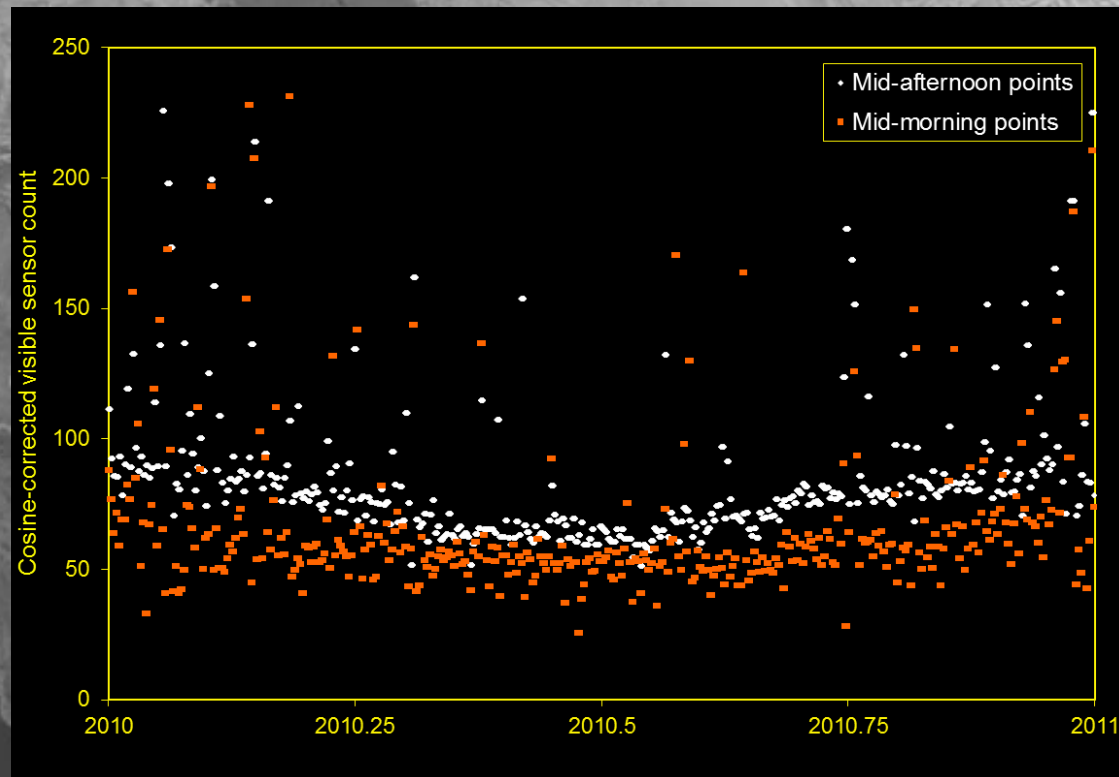
**DARK (clear)**

**WHITE (cloudy)**

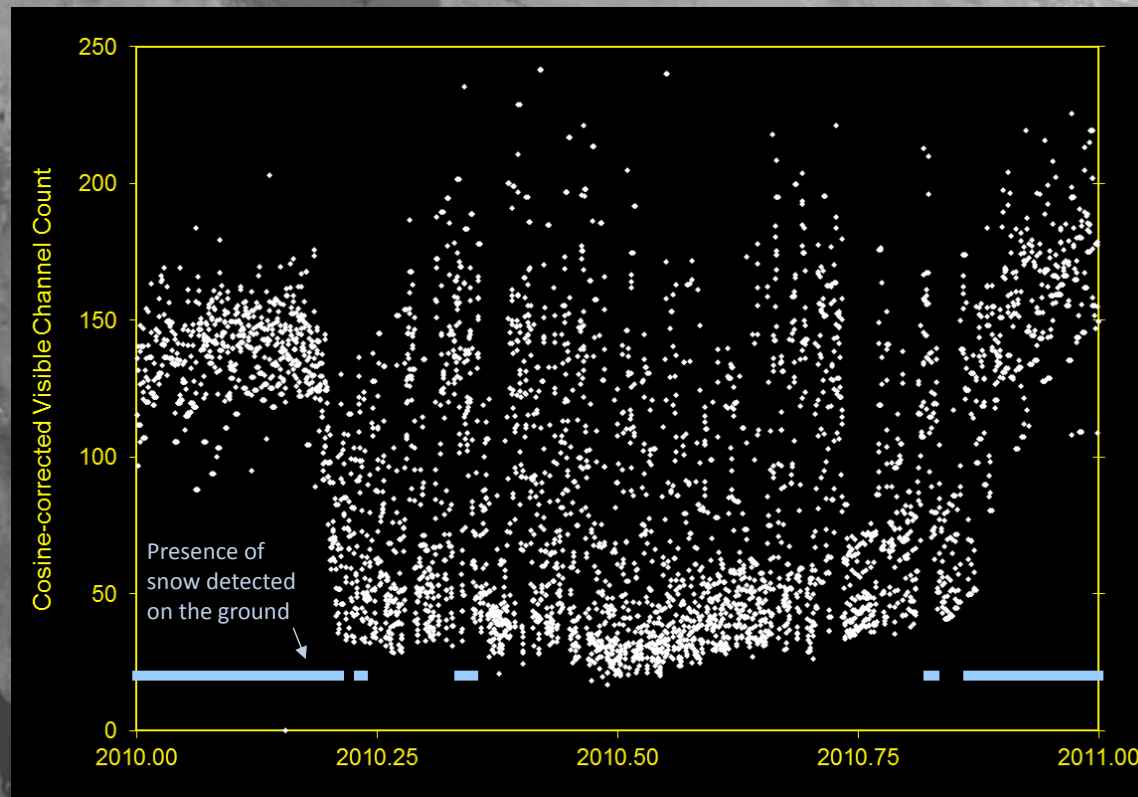




# Specular Reflectivity Must Be Accounted for

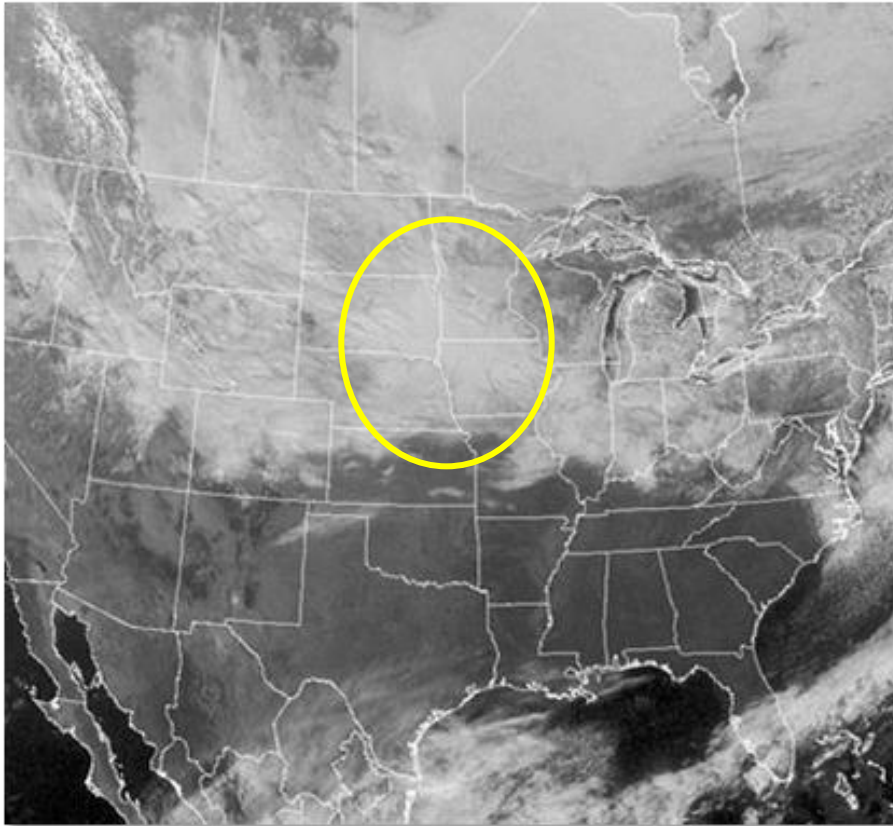


# Snow Must Be Accounted for



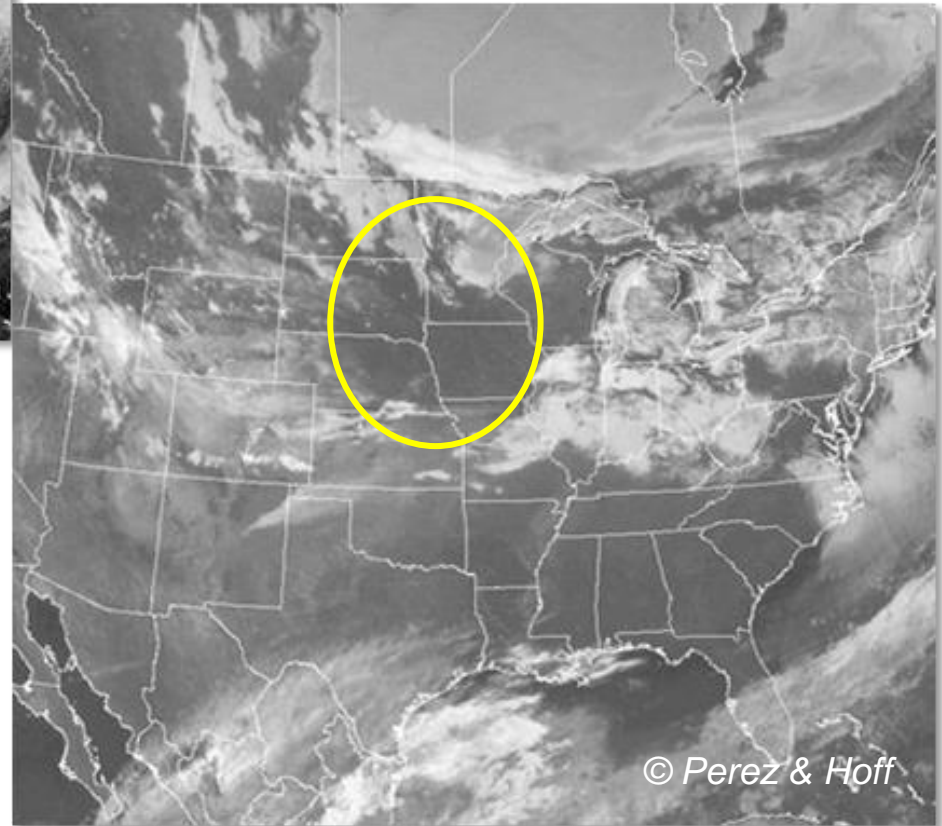
**DARK (clear)**

**WHITE (cloudy)**



Visible Channel

IR Channel Combination



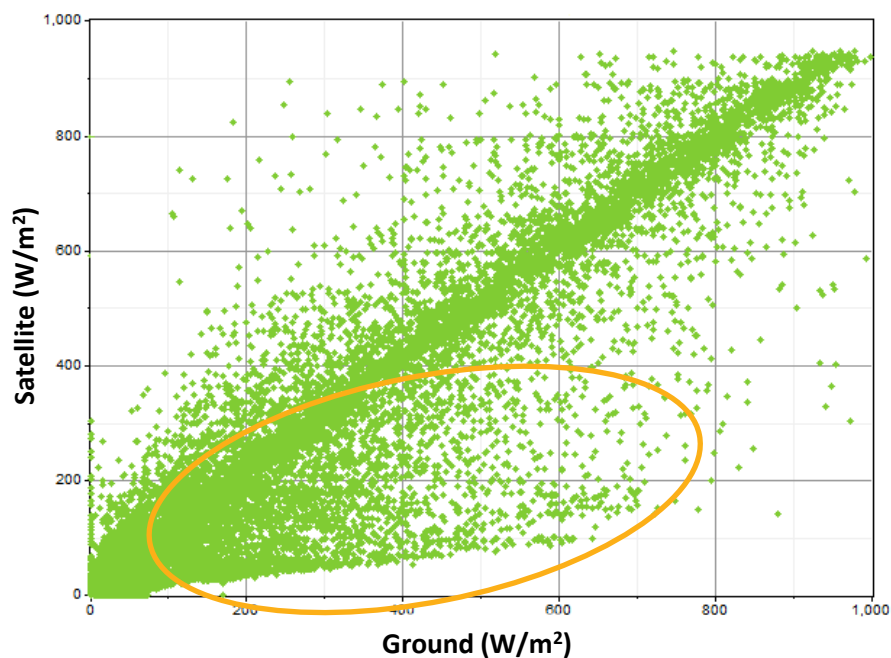
Clean Power Research®

© Perez & Hoff

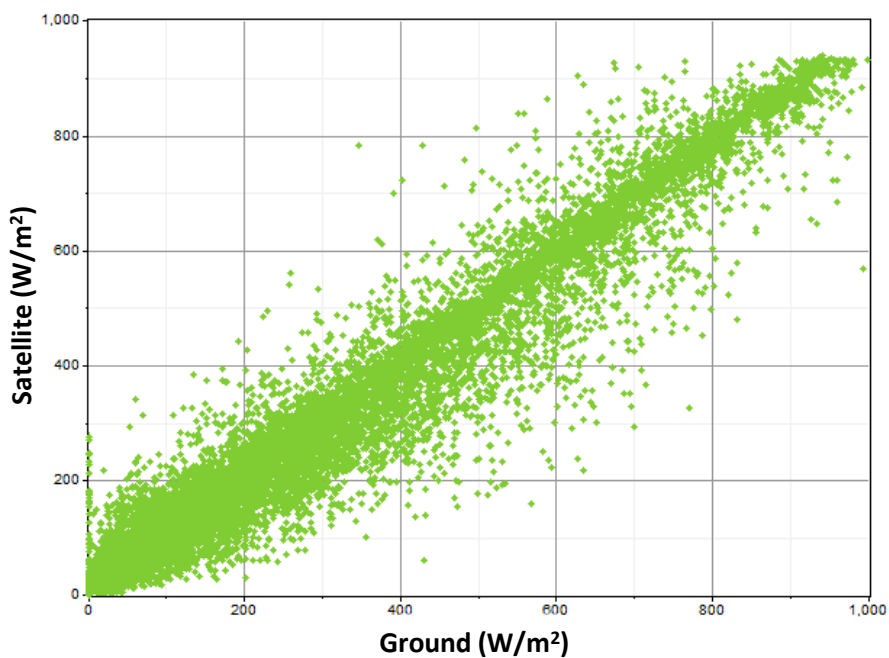


# Visible + IR: Better Snow Discrimination

## Visible Model



## Visible + IR Model



**Fort Peck, MT**

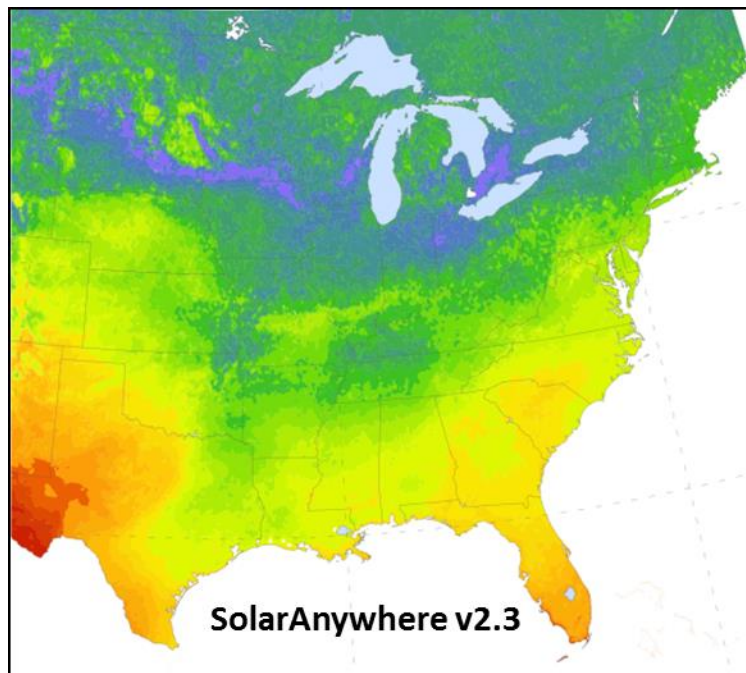


Clean Power Research®

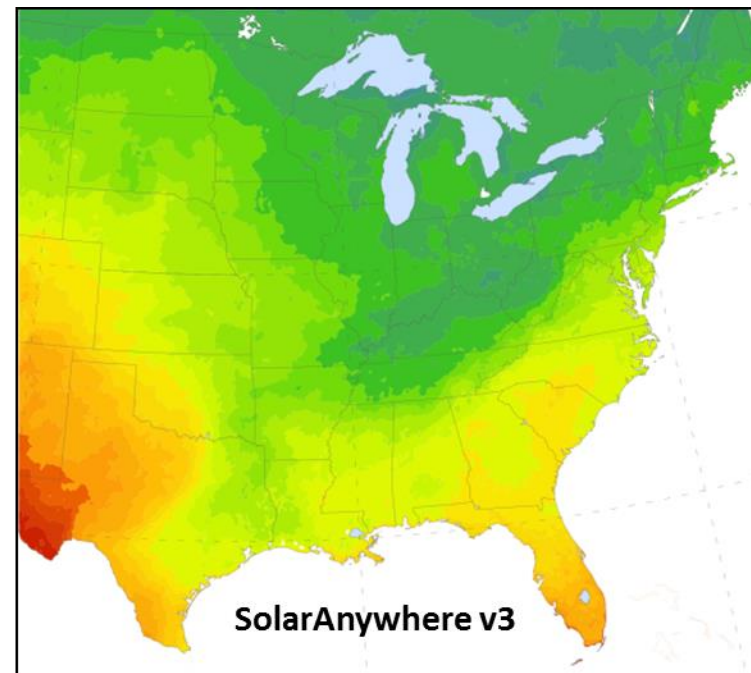
© Perez & Hoff

# Visible + IR: Better Snow Discrimination

Visible Model



Visible + IR Model



Monthly Average Global Horizontal Irradiance ( $\text{W}/\text{m}^2$ )

February 2011

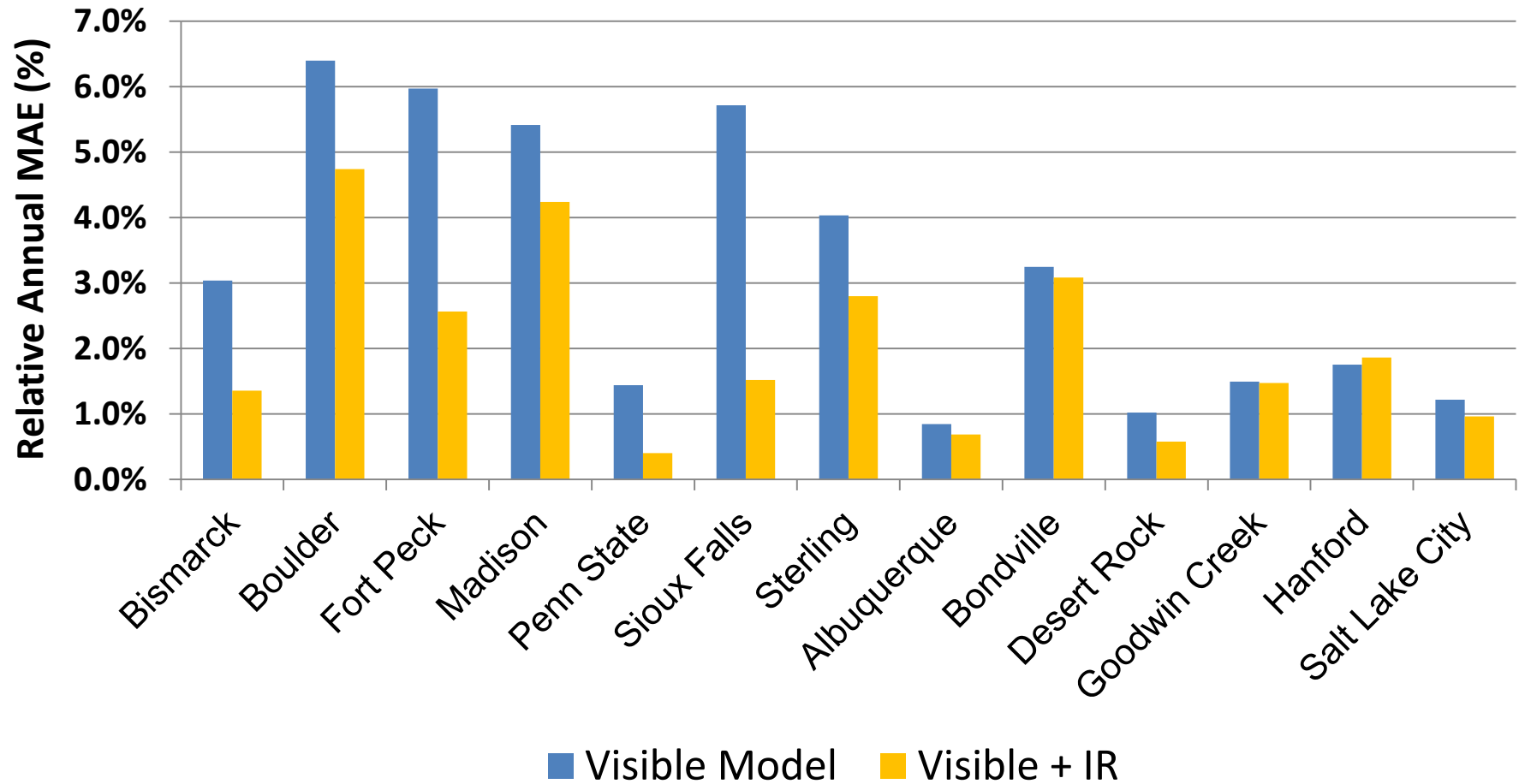


Clean Power Research®

© Perez & Hoff

# Satellite Model Error Characteristics

## GHI



2010-2012 Observations

© Perez & Hoff

# Agenda

- The Evolution of Solar Irradiance Modeling and Datasets
- Satellite-based Irradiance Modeling
- **TMY Data Considerations**
- Which Data Should I Use?



# TMY3 Data Locations (All Classes)



Clean Power Research®



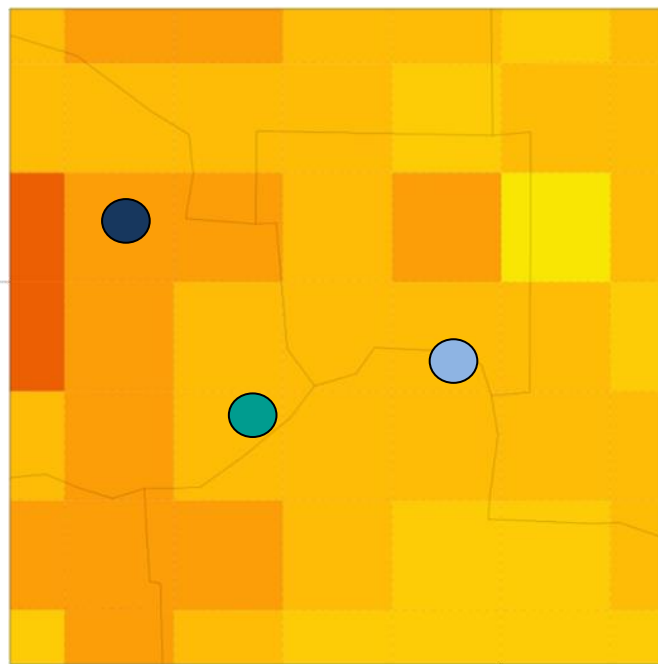
# Not All TMY3 Locations Are Created Equal

	% of Sites	Uncertainty	# of Years Sampled (Generally)
<b>Class I</b>	16%	Lowest	24 years
<b>Class II</b>	43%	Higher	12 years
<b>Class III</b>	41%	Highest	12 years + missing data

Only 40 sites have measured solar data (<2%)  
Pre-1998 = METSTAT modeled  
1998-2005 years = Satellite modeled

# TMY3 Data Locations (Class Differences)

## Minneapolis/St. Paul Example



- TMY3\_Minneapolis-St. Paul Int. Airport (Class I)
- TMY3\_St. Paul downtown Airport (Class II)
- TMY3\_Minneapolis/Crystal (Class II)

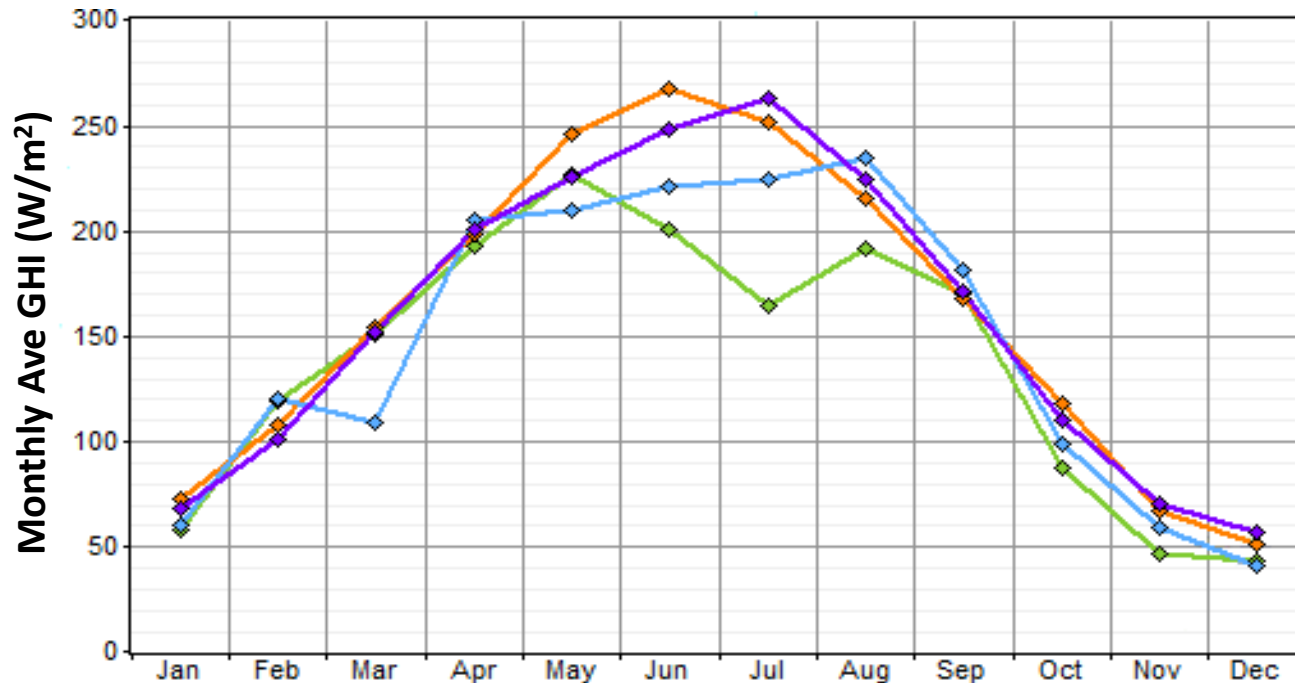


146 148 150 152 154 156 158 160 162 164

Annual Ave GHI ( $\text{W/m}^2$ )

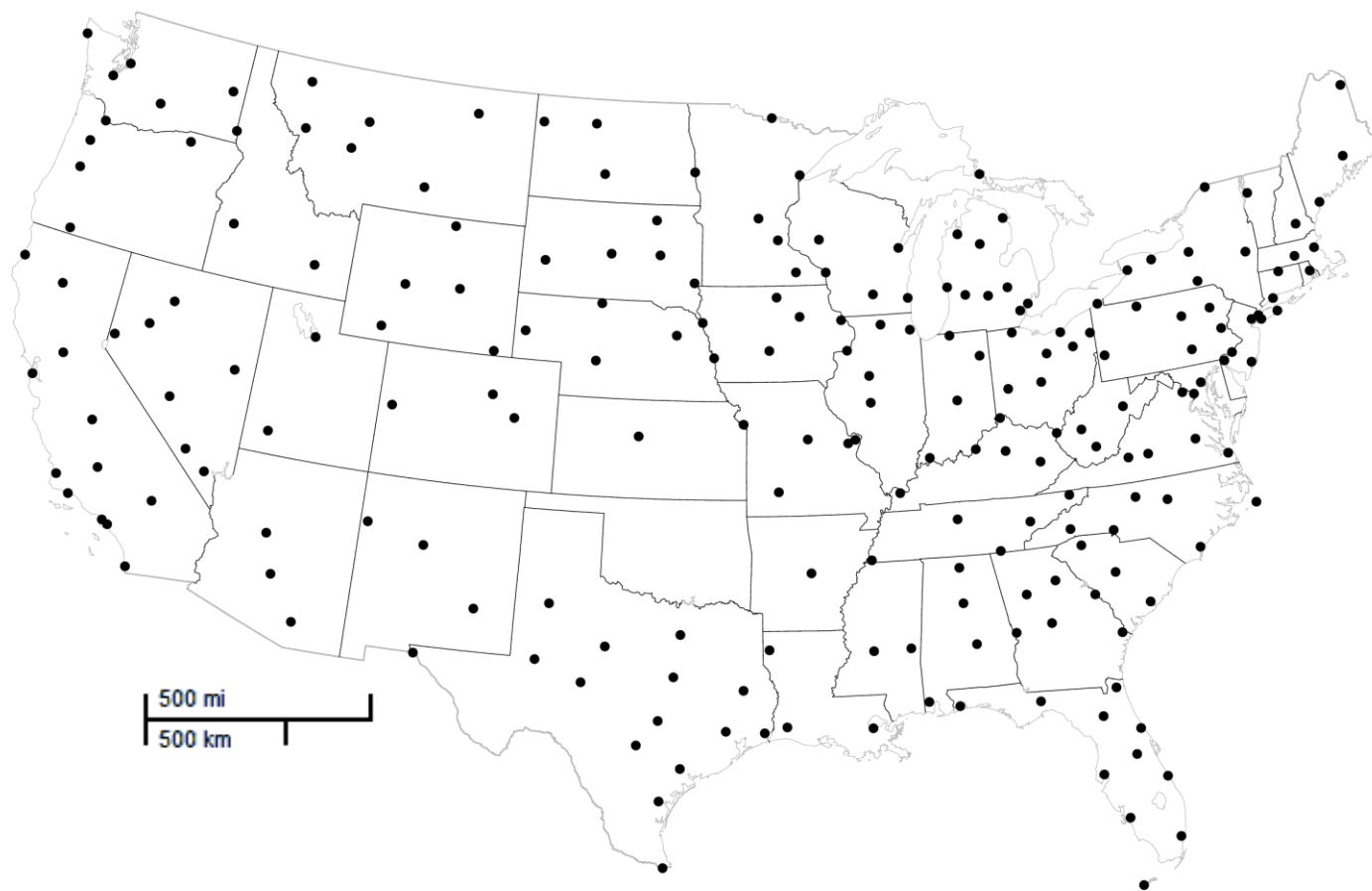
# TMY3 Data Locations (Class Differences)

## Minneapolis/St. Paul Example



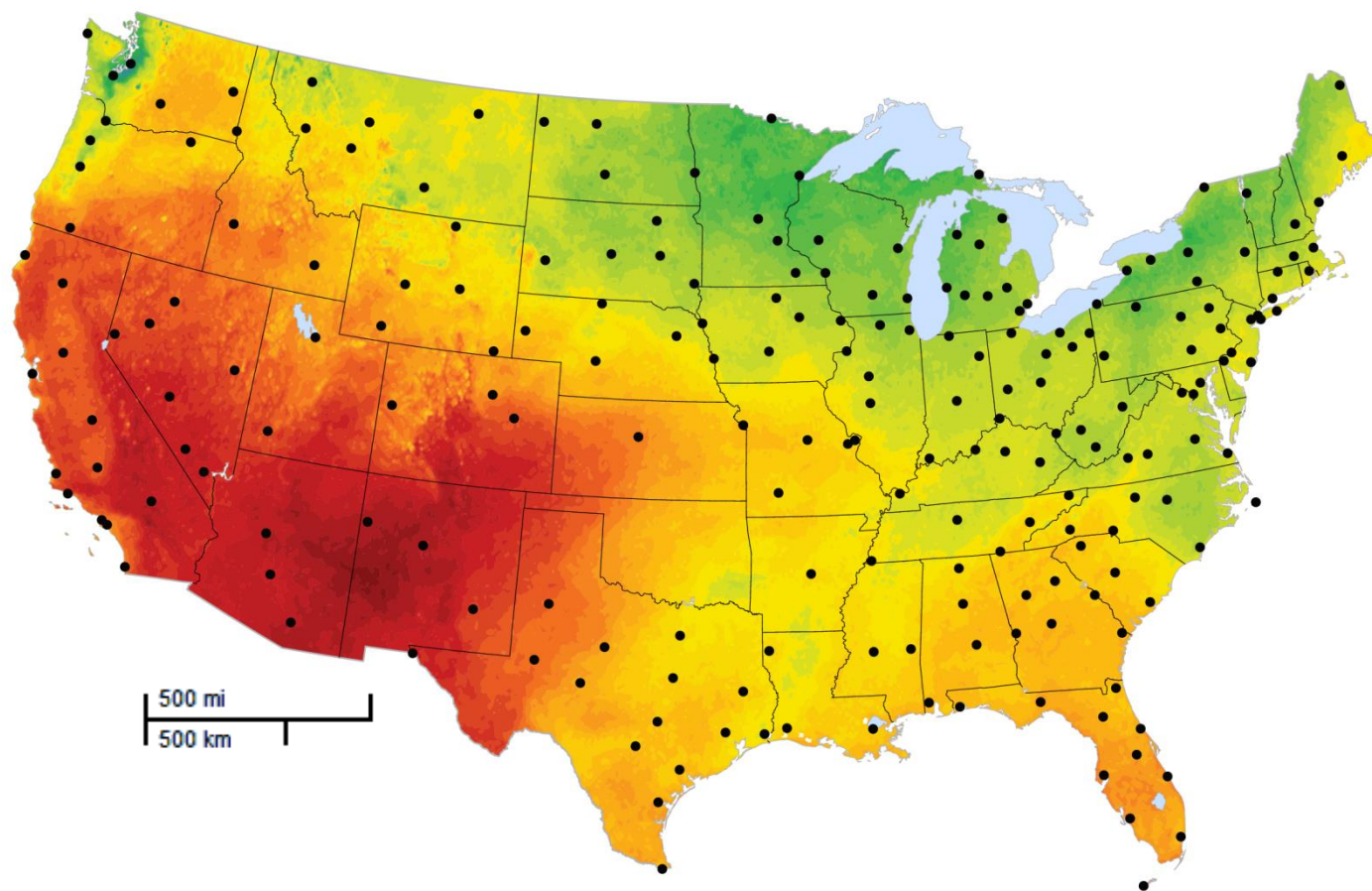
	TMY3 Minneapolis/Crystal	Class II
	TMY3 St. Paul Downtown Airport	Class II
	TMY3 Minneapolis/St. Paul Airport	Class I
	SolarAnywhere Satellite	

# TMY3 Data Locations (Class I)



Clean Power Research®

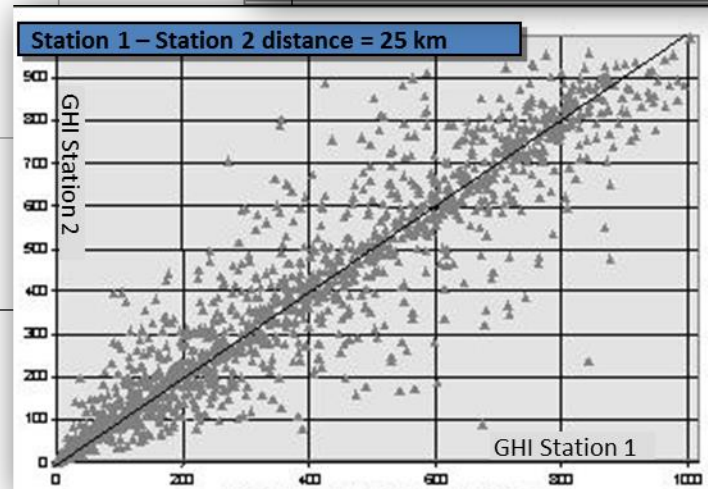
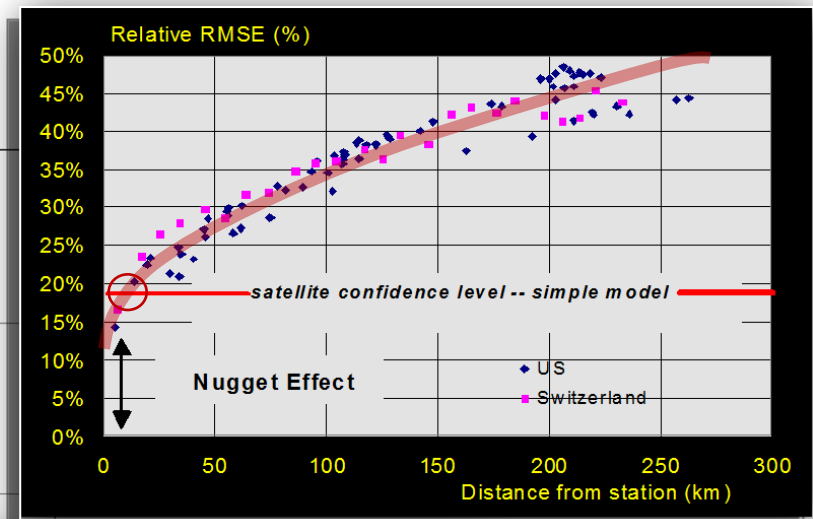
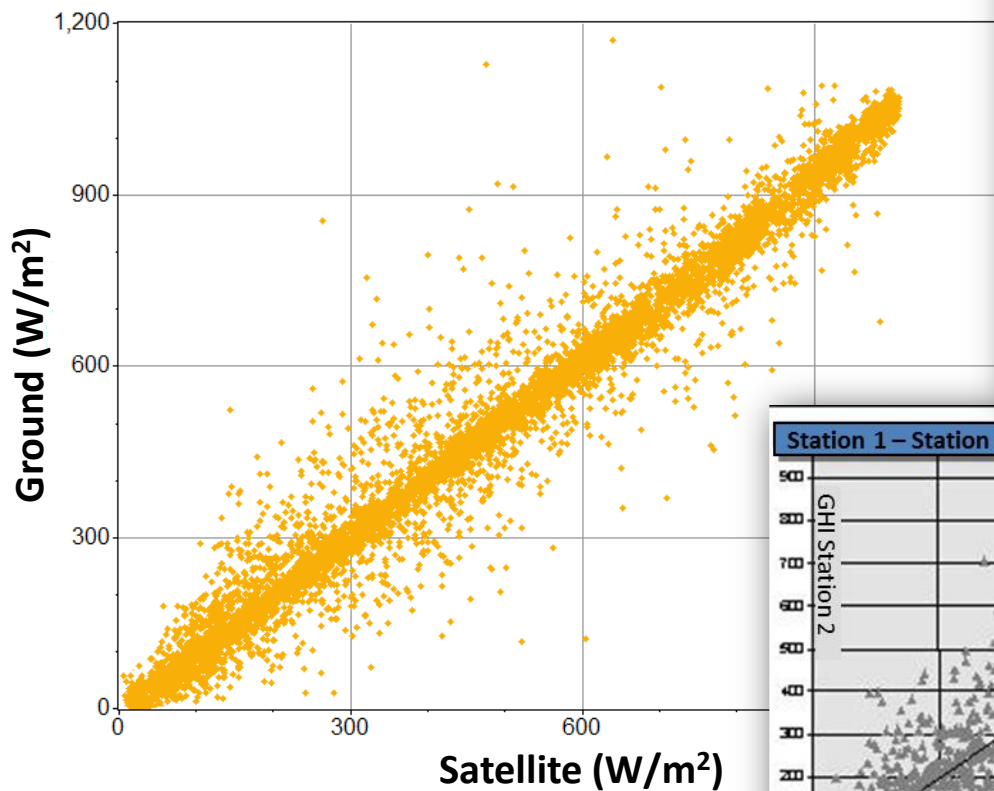
# TMY3 (Class I) and Satellite-based Data



Clean Power Research®

# Error as a Function of Distance

Hanford, CA



# Agenda

- The Evolution of Solar Irradiance Modeling and Datasets
- Satellite-based Irradiance Modeling
- TMY Data Considerations
- Which Data Should I Use?



# Which Dataset Should I Use?

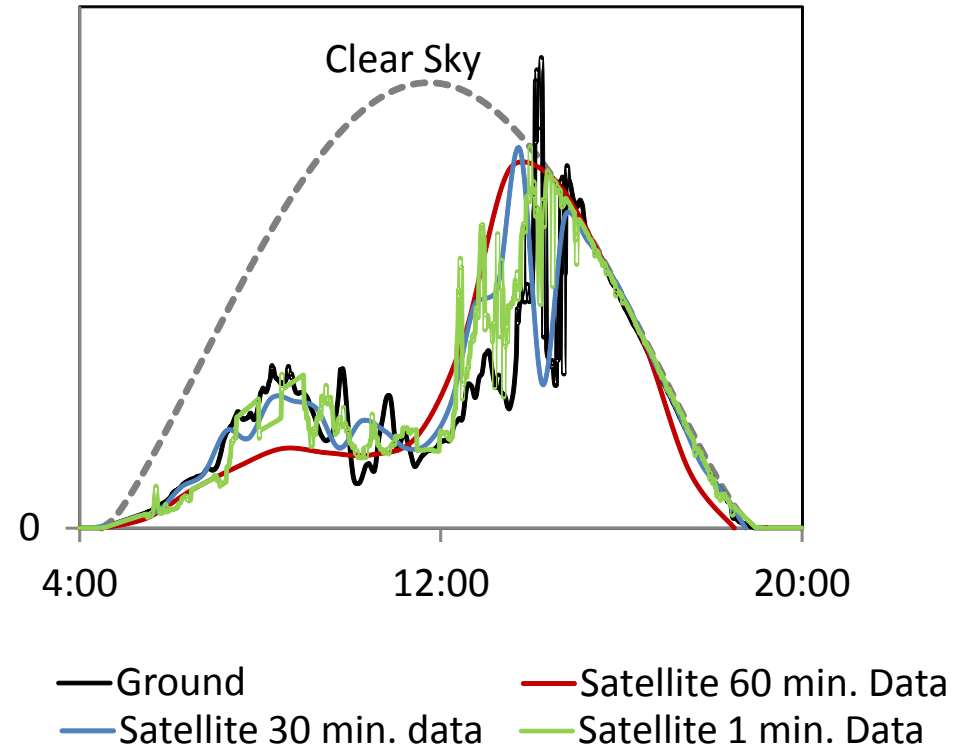
Use Cases	TMY/ TGY	Ground	Satellite
Initial Estimates	✓		
Siting & Financing of Utility Scale PV Systems		✓	✓
Production Guarantees for DG Lease Funds			✓
Real-time Monitoring		✓	✓





# More than One Flavor of Satellite Data

- Spatial Resolution
- Temporal Resolution
- Length of Coverage
- Time-frame
- Tuned/Not-Tuned
- Ancillary Weather Data





# Thank you

*Please feel free to contact us for any details or clarification related to presentation*

Mark McKahan-Jones  
Senior Account Executive  
[mmj@cleanpower.com](mailto:mmj@cleanpower.com)

Adam Kankiewicz  
SolarAnywhere Research Spec.  
[adamk@cleanpower.com](mailto:adamk@cleanpower.com)

Skip Dise  
SolarAnywhere Prod. Manager  
[johndise@cleanpower.com](mailto:johndise@cleanpower.com)



Clean Power Research®

Copyright © 2014 Clean Power Research, L.L.C

v040714